Infrastructure Health & Safety Association

Safe Practice Guide

Live Line Tool Techniques

Foreword

This Guide designates the practices that should be followed by the member firms of the Infrastructure Health & Safety Association (IHSA) when involved in overhead live line tool techniques. This Guide is not designed as a training manual, but contains information, best practices and general recommendations deemed appropriate to perform a job in a responsible and safe manner.

The contents of this Safe Practice Guide, including all advice, recommendations and procedures, are provided as a service by the Infrastructure Health & Safety Association. No representation of any kind is made to any persons whatsoever with regard to the accuracy, completeness or sufficiency of the information contained herein. Any and all use of or reliance on this Safe Practice Guide and the information contained herein is solely and entirely at the user's risk. The user also acknowledges that the safe practices described herein may not satisfy all requirements of Ontario law.

The Infrastructure Health & Safety Association wishes to express its appreciation to those who assisted in the preparation of this Guide.

All rights reserved. This publication may not be reproduced, in whole or in part, without the express written permission of the copyright owner.
# TABLE OF CONTENTS

## INTRODUCTION

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

## SECTION I
### GENERAL INSTRUCTIONS:
#### TESTING, CARE AND USE OF EQUIPMENT

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Testing</td>
</tr>
<tr>
<td>101</td>
<td>Artificial Insulating Materials</td>
</tr>
<tr>
<td>102</td>
<td>Rigid Cover-up Equipment</td>
</tr>
<tr>
<td>103</td>
<td>Safe Execution of Work</td>
</tr>
<tr>
<td>104</td>
<td>Safe Limits of Approach (Authorized Workers)</td>
</tr>
</tbody>
</table>

## SECTION II
### CALCULATION OF FORCES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>General</td>
</tr>
<tr>
<td>201</td>
<td>Conductor Weight Calculation</td>
</tr>
<tr>
<td>202</td>
<td>Calculation of the Tension in a Conductor</td>
</tr>
<tr>
<td>203</td>
<td>Forces Acting on a Dead-end Pole</td>
</tr>
<tr>
<td>204</td>
<td>Guy Tension</td>
</tr>
<tr>
<td>205</td>
<td>Wire Tong Application and Cantilever Loading</td>
</tr>
<tr>
<td>206</td>
<td>Calculation of Cantilever Loading</td>
</tr>
<tr>
<td>207</td>
<td>Application of Calculations of Forces</td>
</tr>
<tr>
<td>208</td>
<td>Bisect Tension</td>
</tr>
</tbody>
</table>
209  Ropes, Rope Blocks and Hoists  34
210  Pull on the Fall Line  38

### SECTION III
**PREPARATION FOR WORK**

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>General</td>
<td>42</td>
</tr>
<tr>
<td>301</td>
<td>Conductor Reference Charts</td>
<td>44</td>
</tr>
</tbody>
</table>

### SECTION IV
**SPECIFIC JOB PRACTICES AND PROCEDURES**

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Change Crossarm and Insulators on a Tangent Structure</td>
<td>48</td>
</tr>
<tr>
<td>401</td>
<td>Change Double Crossarms – Angle Structure</td>
<td>53</td>
</tr>
<tr>
<td>402</td>
<td>Change Insulators on a Vertical Dead-end Structure</td>
<td>58</td>
</tr>
</tbody>
</table>
INTRODUCTION

This Guide has been compiled to familiarize personnel with specialized techniques, work practices, tools and equipment necessary to carry out work on energized circuits.

In order for utilities to provide continuity of service, live line maintenance on energized distribution and transmission lines is required.

Because of the critical nature of this work by live line crews, the tools used must be manufactured under rigid control and individually tested to prove their dielectric and mechanical strength. In order to maintain the mechanical and dielectric characteristics of these tools, a complete knowledge of their care and maintenance is imperative.

The use of live line tools began many years ago when line personnel used crude, homemade tools to work on energized apparatus. Their work eventually led to the present practice of live line maintenance.

One of the most important parts of a live line tool is the insulated pole. It provides the dielectric strength that protects the worker. It is also the most easily damaged and requires the greatest care in manufacturing, testing and maintenance.

During the mid 1950s, commercial fibreglass tubing was introduced into the manufacture of live line tools. This material had high dielectric qualities, but the hollow characteristic was susceptible to moisture generation within the member.
Manufacturers of live line tools have minimized the problem of moisture generation within the tool by adding a unicellular plastic foam core.

These manufacturing methods add superior dielectric and mechanical strength to the members.
SECTION I
GENERAL INSTRUCTIONS:
TESTING, CARE AND USE OF EQUIPMENT

100  TESTING
101  ARTIFICIAL INSULATING MATERIALS
102  RIGID COVER-UP EQUIPMENT
103  SAFE EXECUTION OF WORK
104  SAFE LIMITS OF APPROACH
     (AUTHORIZED WORKERS)
SECTION I
GENERAL INSTRUCTIONS:
TESTING, CARE AND USE OF EQUIPMENT

100 TESTING
Visual checks of live line tools should be carried out on a day to day basis.

If cracks are found, repairs should be made as soon as possible, and the tools retested before use.

Electrical retesting of live line tools should be completed on a regular basis by an approved testing laboratory at least every three years. Wooden tools are not to be used in live line applications in accordance with current Electrical Utility Safety Rules (EUSR).

101 ARTIFICIAL INSULATING MATERIALS
Fibreglass and/or Epoxiglas® tools should be inspected regularly, checking for longitudinal cracks or checks which may trap contaminants.

It is recommended that electrical retesting be done at least every three years by an approved testing laboratory. If tools are properly maintained, they will indefinitely retain a dielectric strength of 100 kV per 0.30 m (1 ft.).

NOTE: All live line tools should be stored, transported and maintained in the best possible condition, keeping them clean and dry.

Keep live line tools stored in a dry trailer on padded racks until ready for use, then place them near the work area, on a portable tool rack or on a clean, dry tarp.

Welding or brazing of broken metal components is not recommended. They should be discarded.
For further information regarding maintenance, use and testing of live line tools and equipment, consult the respective manufacturer.

102 RIGID COVER-UP EQUIPMENT

1. Description

Work methods on subtransmission lines may require the use of cover-up equipment (guards) to cover conductors, hardware, crossarms, poles and other objects which are in the immediate work area and are at different potentials.

Rigid cover-up equipment is retested in accordance with the current ASTM standard.

<table>
<thead>
<tr>
<th>Protective Equipment</th>
<th>Maximum Use Voltage phase to phase</th>
<th>Retest Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 2</td>
<td>14,600 V</td>
<td>1 year</td>
</tr>
<tr>
<td>Class 3</td>
<td>26,400 V</td>
<td>1 year</td>
</tr>
<tr>
<td>Class 4</td>
<td>36,600 V</td>
<td>1 year</td>
</tr>
<tr>
<td>Class 5</td>
<td>48,300 V</td>
<td>1 year</td>
</tr>
<tr>
<td>Class 6</td>
<td>72,500 V</td>
<td>1 year</td>
</tr>
</tbody>
</table>

Classes are positively identified by a stamp on the rigid cover-up equipment, indicating the phase to phase rating.

Conductor guards rated 25 kV phase to phase do not have an air gap between the outer shell of the guard and the conductor and, therefore, are easily recognized as 25 kV rated equipment.

Conversely, conductor guards rated 46 kV phase to phase have an air gap between the conductor and the outer shell of the unit.
Insulator hoods are designed to connect only with conductor guards of the same rating.

**Conductor Guards** – 46 kV phase-to-phase are of two distinct types:

(a) **Wrap Around** – usually made of ABS plastic.

**NOTE:** These may become brittle at temperatures below -18 degrees Celsius (0 degrees Fahrenheit).

(b) **Snap On** – manufactured using polyethylene materials and incorporate an air gap to increase protection.

**NOTE:** No appreciable embrittlement to -25 degrees Celsius (-13 degrees Fahrenheit).

**Miscellaneous Rigid Cover-up** – The following are available in both basic materials:

(a) Crossarm guards
(b) Cutout covers
(c) Pole covers – (i) ribbed – reduces contact with pole,
   (ii) unribbed – direct contact with pole.

**NOTE:** Pole covers are limited to two diameters: 23 cm (9 in.) and 30 cm (12 in.)

(d) Dead-end covers

Ensure appropriate rating for voltage level being worked on.

2. **Inspection**

All rigid cover-up material should be thoroughly inspected prior to use.

Cleaning of rigid cover-up material should be completed on a regular basis, especially when
guards are used in chemically contaminated areas. This helps ensure the dielectric capabilities of the equipment are maintained.

Petroleum-based products, inhibitors, etc. should not be allowed to remain on rigid cover-up equipment for extended periods of time.

**NOTE:** The use of isopropanol as a cleaning agent is recommended.

3. **Examination**

   **Welds** – Careful visual examination of metal attachments, to pick up signs of metal fatigue or cracking, should be completed prior to use.

   Puncture holes, cracks in the finish or splitting ends may be observed at this time. The unit should be tested prior to use, if the dielectric integrity is compromised.

   **Field Patches** – Field patches are not permissible on fibre protective equipment.

   Should the dielectric effectiveness of the cover-up (guards) become suspect, the guards should be submitted for inspection and retest.

4. **Retesting**

   Fibre protective equipment shall be laboratory tested at least every 12 months, or more often should this equipment become suspect.

5. **General Use**

   (a) Conductor guards and associated cover-up equipment are not intended to allow personnel to reduce required clearances, but rather to protect against inadvertent brush contact.

   (b) Maintain limits of approach to exposed energized conductor in accordance to the EUSR.

   (c) When two conductor guards are used to increase the length of protection, it is imperative
that the guards are properly interlocked.

(d) Although pole covers are intended to be used when/where an energized conductor could make contact, the covers are not designed to be left in place any longer than absolutely necessary.

(e) Should a pole guard be required to prevent conductor contact with the pole, the guard(s) should be positioned to provide maximum protection.

6. Storage
(a) Rigid cover-up equipment should be stored in a specific bin, box or trailer to protect it from contamination and abuse.

(b) ABS units should be stored securely to prevent end to end movement, since the ends could easily become damaged.

103 SAFE EXECUTION OF WORK
The safe execution of live line tool technique requires:
- competent personnel
- job planning
- safe work methods
- teamwork

1. Competent Personnel
Only competent personnel, or personnel in training under the continuous direction of competent personnel, should implement the live line tool technique.

NOTE: All work should be carried out on a “go slow” basis until the personnel in training become proficient in this technique.

2. Job Planning
As in all other phases of line work, job planning is of prime importance to ensure that the work may be performed safely and efficiently. Consideration must be given to weights and tensions relieved and/or supported by the live line tool(s).
3. **Safe Work Methods**  
The methods to be used in the live line tool technique must be reviewed thoroughly with the crew performing the particular task.

The method(s) adopted for a specific job should be followed as originally planned. Any variation from these specifics should be discussed and thoroughly understood by everyone involved.

4. **Teamwork**  
The best teams are made up of people who will work compatibly with one another. Effective communication is essential while work is being performed.

Only when these requirements are met can the job be performed safely and efficiently.

104 **SAFE LIMITS OF APPROACH**  
(AUTHORIZED WORKERS)

For specific limits of approach, when performing live line tool techniques, refer to current EUSR.
SECTION II
CALCULATION OF FORCES

200 GENERAL
201 CONDUCTOR WEIGHT CALCULATION
202 CALCULATION OF THE TENSION IN A CONDUCTOR
203 FORCES ACTING ON A DEAD-END POLE
204 GUY TENSION
205 WIRE TONG APPLICATION AND CANTILEVER LOADING
206 CALCULATION OF CANTILEVER LOADING
207 APPLICATION OF CALCULATIONS OF FORCES
208 BISECT TENSION
209 ROPES, ROPE BLOCKS AND HOISTS
210 PULL ON THE FALL LINE
SECTION II
CALCULATION OF FORCES

All metric/imperial conversions in this section are approximations only. The following is a reference for abbreviations used.

\[
\begin{align*}
  m & \text{ - metre} & ft. & \text{ - foot (feet)} \\
  kg & \text{ - kilogram} & in. & \text{ - inch} \\
  cm & \text{ - centimetre} & lb. & \text{ - pound} \\
  km & \text{ - kilometre} & lbs. & \text{ - pounds} \\
  mm & \text{ - millimetre} & ° & \text{ - degrees}
\end{align*}
\]

200 GENERAL
Personnel working with live line tools must be trained to recognize the hazards associated with improper rigging procedures and the misapplication of tools.

To accomplish this, they should fully understand the intended use of the tools, the limitations of the tools, and the weights and forces that will be encountered.

Some line configurations may require careful consideration of the forces to be exerted on the tools. These forces may control the method of application. The design of live line tools is such that, if recommended rigging procedures are followed, the mechanical limitations of the tools will not be exceeded.

The following procedure is a guide to the calculation of forces acting on live line tools on a tangent structure.

201 CONDUCTOR WEIGHT CALCULATION
Theoretically, the physical weight of a conductor consists of the weights of the two half spans adjacent to the structure being worked. (See Figure #1) To allow for
variables, the physical weight should be multiplied by a predetermined safety factor.

It must be noted that, as a conductor is raised off a tangent structure, the sag is decreased to the point where the physical weight begins to increase. For this reason, a safety factor of 2 is used in short span calculations, and 1.5 in long span calculations.

To calculate the weight of a conductor, the following formulas are used:

1. Short spans (Up to 76 m or 250 ft.)
   \[
   \text{Weight} = \text{Span “A”} + \text{Span “B”} \times W \times (\text{safety factor})^2
   \]
   \[
   \frac{2}{2}
   \]
   \[
   \text{Weight} = \text{physical weight to be lifted} + \text{safety factor}
   \]
   \[
   W = \text{kg per m (lbs. per ft.) of conductor}
   \]
   \[
   2 = \text{constant multiple for safety factor on spans up to 76 m (250 ft.)}
   \]

**Example**
In Figure #1:
The conductor is 336,400 ACSR weighing 689 kg per km (463 lbs. per 1,000 ft.).
689 kg divided by 1,000 m = 0.689 kg per m
(463 lbs. divided by 1,000 ft. = 0.463 lbs. per ft.)
Metric weight = \[ \frac{61 + 61 \times 0.689 \times 2}{2} = 84 \text{ kg} \]

Imperial weight = \[ \frac{200 + 200 \times 0.463 \times 2}{2} = 185 \text{ lbs.} \]

2. Long spans - (Over 76 m or 250 ft.)

Weight = \[ \frac{\text{Span “A”} + \text{Span “B”} \times W \times 1.5}{2} \]

\[ W = \text{kg per m (lbs. per ft.) of conductor.} \]

\[ 1.5 = \text{constant multiple for safety factor on spans over 76 m (250 ft.)} \]

Example

In Figure #2:

The conductor is 336,400 ACSR weighing 689 kg per km (463 lbs. per 1,000 ft.).

689 kg divided by 1,000 m = 0.689 kg per m
(463 lbs. divided by 1,000 ft. = 0.463 lbs. per ft.)

Metric weight = \[ \frac{82 + 79 \times 0.689 \times 1.5}{2} = 83.5 \text{ kg} \]

Imperial weight = \[ \frac{270 + 260 \times 0.463 \times 1.5}{2} = 184 \text{ lbs.} \]
When lifting a conductor at a tangent structure there are other forces which need to be considered. These are caused by the increase in tension due to the lifting movement which decreases the sag in the line, therefore, exerting additional loading on the tools.

Large conductor and high lifts must be calculated and watched carefully.

Now that we are able to calculate the weight of a conductor, we must have a good working knowledge of proper rigging procedures to move these conductors without placing undue stress on the lifting tools.

Figure #3 – incorporated in this diagram is:

3.8 cm x 3 m – wire tong "A" (1½ in. x 10 ft.)
6.3 cm x 3.6 m – wire tong "B" (2½ in. x 12 ft.)
Wire tong band and swivel "C" rope blocks.

Maximum working load = 215 kg (475 lbs.) per conductor with wire tong band at 76 cm (30 in.)

Using the tool arrangement shown in Figure #3, the maximum working load per conductor is 215 kg (475 lbs.).

The weight of the conductor having been predetermined at 84 kg (184 lbs.) indicates the rigging procedures are adequate to carry the weight involved, and the live line

![Figure #3](image)
tools will not be overloaded.

202 CALCULATION OF THE TENSION IN A CONDUCTOR

In many cases, it will be helpful in calculating the mechanical load to be imposed on the tools by knowing the tension in a conductor.

The formula for calculating the tension in a conductor is:

$$ T = \frac{W \times \text{Span}^2}{8 \times \text{sag in m (ft.)}} \tag{1} $$

- $T$ = Tension
- $W$ = kg per m of conductor (lbs. per ft. of conductor)
- Span = Adjacent to the dead-end or on either side of the pole being worked
- 8 = Constant
- Sag = Sag of the span in m (ft.)

Example

Determine the tension of a 336,400 ACSR conductor in a 61 m (200 ft.) span having a sag of 1.07 m (3.5 ft.).

- $W = 689$ kg per km or 0.689 kg per m (463 lbs. per 1,000 ft. or 0.463 lbs. per ft.)
- Sag = 1.07 m (3.5 ft.)
- Span = 61 m (200 ft.)

Therefore:

Metric tension = $\frac{0.689 \times 61 \times 61}{8 \times 1.07} = 300$ kg (rounded)

Imperial tension = $\frac{0.463 \times 200 \times 200}{8 \times 3.5} = 660$ lbs.
Now that we are able to calculate the tension in a conductor, we can calculate other important forces. Using a dead-end pole as an example, we can find:

(a) the vertical force attempting to push the pole into the ground (compressive force)

(b) the tension on the guy wire

Compare the dotted triangle in Figure #5 with the triangle formed by the pole and ground line. We will assume that the base of the dotted triangle is the same length as the base of the solid triangle. This 6 m (20 ft.) equals a 300 kg (660 lbs.) horizontal force.
300 kg (660 lbs.) = 49.2 kg (33 lbs.) force per m (ft.)

Apply this scale to the pole, which is 12.2 m (40 ft.):

12.2 m (40 ft.) x 49.2 kg (33 lbs.) = 600 kg (1,320 lbs.)
compressive force pushing down on the pole.

The formula for the calculation of compressive force is:
tension divided by anchor distance times pole height.
In this case:

\[
\frac{300 \text{ kg (660 lbs.)} \times 12.2 \text{ m (40 ft.)}}{6 \text{ m (20 ft.)}} = 600 \text{ kg (1,320 lbs.) compressive force}
\]

204 GUY TENSION

To find the tension in the guy, we must find its length.
Solve for the hypotenuse of a right angled triangle.

Metric: \(12.2^2 + 6^2 = 148.8 + 37.2 = 185 \text{ m}\)
Imperial: \(40^2 + 20^2 = 2,000 \text{ ft.}\)

Find square root of 185 m (2,000 ft.) = 13.6 m (45 ft.)

Guy length = 13.6 m (45 ft.)

Guy tension = 13.6 m x 49.2 kg per m = 669 kg (1,485 lbs.) tension.

The formula for guy tension is: Tension divided by anchor distance times guy length. In this case:

\[
\frac{300 \text{ kg (660 lbs.)} \times 13.7 \text{ m (45 ft.)}}{6 \text{ m (20 ft.)}} = 685 \text{ kg (1,485 lbs.) tension}
\]

A simple method of calculating mechanical force is to draw a right-angled triangle to scale, representative of the problem. A ruler divided in centimetres may be useful.

NOTE: As the anchor distance increases, the guy tension decreases. (See Figure #6) Therefore, the compressive force acting on the
pole decreases as the anchor distance increases.

Bisect tension can be described as the force exerted by a conductor on a corner tending to pull the pole into line.

The formula for calculating bisect tension is:

\[
\text{Bisect tension} = \text{line tension} \times \text{size of the angle}
\]

Figure #6

Line tension: 100 kg (220 lbs.)
Pole height: 10 m (33 ft.)
If the angle of the line is not given on engineered drawings, it will be necessary to determine it in the field. A quick method used in the field is to take 19 paces (57 feet) in line with one conductor from the pole. Measure 57 feet along a continued imaginary line from the other conductor in Figure 7, the distance between C and B in feet will provide the approximate angle in the line in degrees.

![Figure #7](image)

For example, if the distance between B and C is 45 feet, then the angle is 45°. If the distance between B and C is 15 feet then the angle is approximately 15°.

**Note:** This method only works using the imperial system. The formula indicates line tension must be determined before you can calculate bisect tension.

a) Find the bisect tension of one 3/0 conductor on an angle of 30° where the line tension is 181 kg (400 lbs.).

\[
\text{Bisect tension} = \frac{\text{Line tension} \times \text{size of angle}}{60}
\]
\[
\frac{181 \times 30}{60} = \frac{400 \times 30}{60} = 90.5 \text{ kg} = 200 \text{ lbs.}
\]

When the angle is 30°, the bisect tension is 30/60 or \(\frac{1}{2}\) the full line tension. If the angle is 45°, the bisect tension is 45/60 or \(\frac{3}{4}\) of full line tension.

b) A corner pole of 50° supports a single 336 MCM aluminum conductor sagged at 1.5 m (5 ft.) where the adjacent spans are each 61 m (200 ft.) (336 MCM aluminum weighs 470 kg/km (315 lbs./1,000 ft.). Calculate the bisect tension of the conductor.

\[
\begin{align*}
\text{Line tension} &= \frac{\text{weight/m} \times \text{span}^2}{8 \times \text{sag in metres}} = \frac{\text{weight/ft.} \times \text{span}^2}{8 \times \text{sag in feet}} \\
&= \frac{0.470 \times 61^2}{8 \times 1.5} = \frac{0.315 \times 200^2}{8 \times 5} \\
&= \frac{0.470 \times 3721}{12} = \frac{0.315 \times 40,000}{40} \\
&= 145 \text{ kg} = 315 \text{ lbs.}
\end{align*}
\]

Now we can determine the bisect tension:

\[
\text{Bisect tension} = \frac{\text{Line tension} \times \text{size of the angle}}{60}
\]

\[
\begin{align*}
\frac{145 \times 50}{60} &= \frac{315 \times 50}{60} \\
&= 120.8 \text{ kg} = 262.5 \text{ lbs.}
\end{align*}
\]
**Field Calculation to find Bisect Tension** -
Measure angle of the phase and use the following:

- $15^\circ = 25\%$ of line tension
- $30^\circ = 50\%$ of line tension
- $45^\circ = 75\%$ of line tension
- $60^\circ = 100\%$ of line tension
- $75^\circ = 125\%$ of line tension
- $90^\circ = 150\%$ of line tension

**205 WIRE TONG APPLICATION AND CANTILEVER LOADING**

Fibreglass reinforced plastic insulated tools are very strong in tension and compression, however, extreme care must be exercised when cantilever loads are placed on them.

Wire tongs 3.8 cm (1½ in.) should not be used to support the weight of a conductor in cantilever or compression. A 6.3 cm (2½ in.) wire tong is normally used in this application. The working load limit (WLL) for a 6.3 cm (2½ in.) wire tong in cantilever is approximately 215 kg (475 lbs.).

**Link Sticks**
Link sticks come in three different types: strain link sticks, roller link sticks, and suspension link sticks.

**206 CALCULATION OF CANTILEVER LOADING**

Once the physical weight of the conductor to be lifted has been determined, the cantilever loading may be calculated by drawing, to scale, a right angled triangle representing the tool configuration.

Link sticks are used for pulling or suspending loads. One end is equipped with a swivel or "bull ring" for attaching pulling equipment or ropes. The other end
has a roller head, spiral link or suspension link. Link sticks have a diameter of 3 cm (1-1/4 in.) and come in various lengths. The most common lengths are 0.3 m (1 ft.), 0.4 m (1-1/2 ft.), 0.6 m (2 ft.), and 1.2 m (4 ft.).

A 3 cm (1-1/4 in.) strain link stick has a WLL of 1,587 kg (3,500 lbs.). A 3 cm (1-1/4 in.) roller link stick has a WLL of 453 kg (1,000 lbs.). A 3 cm (1-1/4 in.) suspension link stick has a WLL of 2,948 kg (6,500 lbs.).

Lever Lifts
Lever lifts are used for lifting heavy conductors and when working space on the structure is limited. There are two types of lever lifts: the single lever lift (used for supporting one lifting tong) and the double lever lift (used for supporting two wire tongs).

The WLL of a single lever lift is 680 kg (1,500 lbs.) per tong. The WLL of a double lever lift is 340 kg (750 lbs.) per tong.

Each lever lift is equipped with a safety locking chain binder, for quick application to the pole, and a clevis for attaching rope blocks. Lever lifts are restricted to a maximum lift of 52 cm (20-3/4 in.).

**NOTE:** Never take the lever past horizontal. It will snap into the pole once it is taken over centre.
Extreme care must be taken with hands and feet around the lever lift, when it is being moved.

Wire Tong Saddles
Wire tong saddles are used to secure wire tong sticks to the structure. The saddles come in two sizes: 3.8 cm (1-1/2 in.) for the holding tong, and 6.3 cm (2-1/2 in.) for the lifting tong.

The clamp for holding the wire tongs has a fibre or stainless steel lining and, when tightened, holds the tool in place without damaging the finish of the stick. The surface of the lining should be inspected for burrs to prevent damage to the fibreglass. The clamps should always be kept closed during storage, and when being raised or lowered on a handline. The clamp is tightened onto the stick by hand, and then a maximum of one half turn may be applied, using a screwdriver, if required. The saddle is equipped with a clevis to provide an attachment point for rope blocks.

The WLL of the pole saddle is:
- saddle without extension: 453 kg (1,000 lbs.)
- saddle with extension: 362 kg (800 lbs.)
- slippage weight of wire tong clamp: 170 kg (375 lbs.)

Rope Snubbing Bracket
Rope snubbing brackets are used for snubbing all hand or light block lines. The bracket is mounted on the base of the pole to provide a tying off point for the lines. The snubbing bracket has a WLL of 226 kg (500 lbs.) per ring, to a maximum of 453 kg (1,000 lbs.).

When heavy conductors are to be lifted, or when work is being done on elevated structures on hill tops, special consideration must be given to possible overloads in cantilever. (See Figure #9)
For working load limits of live line tools and attachments, consult the manufacturers' specifications.

To control horizontal movement of heavy conductors, a set of two sheave blocks is used between the wire tong band and the saddle clevice. This procedure creates a cantilever loading on the lifting tong.

Figure #10 shows AB holding tong, BD lifting tong, BE conductor weight, BC distance between jaw of tong
and wire tong band, and CE the horizontal distance between the wire tong band and the conductor.

Example: The loading is found by multiplying the distance CE by the weight of the conductor, which is 90.7 kg = 0.54 m x 90.7 = 49 kg/m (200 lbs. = 1.78 ft. x 200 lbs. = 356 lbs./ft.) cantilever, or the following equation may be used to solve the problem in Figure #11.

**Cantilever load in**

(a) kg/m:

\[
0.76 \times \frac{\text{length of holding tong} \times \text{conductor weight}}{\text{length of lifting tong}}
\]

\[
= 0.76 \times 2.3 \times 90.7 = 49.3 \text{ kg/m}
\] 3.2

(b) lbs./ft.:

\[
2.5 \times \frac{\text{length of holding tong} \times \text{conductor weight}}{\text{length of lifting tong}}
\]

\[
= 2.5 \times 7.5 \times 200 = 357 \text{ lbs./ft.}
\] 10.5

A change in rigging will eliminate excessive cantilever strain on the lifting tong. (See Figure #11)

A wire tong blocks clamp is installed on the holding tong AB at X, and a set of rope blocks connected between here and the clevis of the pole saddle, to assist in supporting the horizontal movement of the conductor.
207 APPLICATION OF CALCULATIONS OF FORCES

The Problem:
To change the pole phase insulator on a 40° corner pole, with spans on either side of 45.7 m (150 ft.) and 53.3 m (175 ft.). The poles are 12.2 m (40 ft.) above ground carrying 4/0 ACSR conductor which has 0.76 m (30 in.) of sag in the 53.3 m (175 ft.) span. The bisect tension will be held by means of a link stick (attached to the conductor) to a side line and rope blocks anchored at 24.3 m (80 ft.) from the pole butt. As previously noted, guying other than horizontally applies vertical stress that must be considered. (See Figure #12)
Actual conductor weight =
4/0 ACSR = 436 kg per km or 0.436 per m
(294 lbs. per 1,000 ft. or 0.294 per ft.)

Weight of conductor =
\[
\frac{45.7 \text{ m} + 53.3 \text{ m} \times 0.436 \times 2}{2} = 43.2 \text{ kg}
\]
(150 ft. + 175 ft. \times 0.294 \times 2 = 95.5 lbs.)

Tension of conductor =
\[
\frac{53.3 \text{ m} \times 53.3 \text{ m} \times 0.436}{8 \times 0.76 \text{ m}} = 204 \text{ kg}
\]
(175 ft. \times 175 ft. \times 0.294 = 450 lbs.)

208 BISECT TENSION

NOTE: One span is not shown for clarity purposes
Using a tape line, we find the distance BD is 5.2 m (17 ft.) in Figure #13. The distance AB – 15 m (50 ft.) – represents tension of 204 kg (450 lbs.).

\[ \frac{1 \text{ m}}{15 \text{ m}} = \frac{204 \text{ kg}}{15 \text{ m}} = 13.6 \text{ kg/m} \]

\[ (1 \text{ ft.} = \frac{450 \text{ lbs.}}{50 \text{ ft.}} = 9 \text{ lbs./ft.}) \]

Therefore, BD = 5.2 x 13.6 = 71 kg

\( (17 \times 9 = 153 \text{ lbs.}) \)

Bisect line BD belongs to two triangles, therefore, we must multiply by two. Bisect tension becomes:

\[ 71 \times 2 = 142 \text{ kg} \]
\[ (153 \times 2 = 306 \text{ lbs.}) \]

or

\[ \text{Bisect tension} = \frac{\text{Tension} \times \text{Bisect line} \times 2}{\text{Measured distance}} \]

\[ = \frac{204 \text{ kg} \times 5.2 \text{ m} \times 2}{15 \text{ m}} = 142 \text{ kg} \]

\[ = \frac{(450 \text{ lbs.} \times 17 \text{ ft.} \times 2}{50 \text{ ft.}} = 306 \text{ lbs.}) \]

Tension on rope guy

\[ = \frac{\text{Bisect tension} \times \text{Guy length}}{\text{Anchor distance}} \]

Guy length = 24.4 m² + 12.2 m² = the square root of 743 (27.3 m)

\[ = (80 \text{ ft.}^2 + 40 \text{ ft.}^2) = \text{the square root of 8,000} \]
\[ = (89.5 \text{ ft.}) \]
Guy tension = \(142 \text{ kg} \times \frac{27.3}{24.4} = 159 \text{ kg}\)

(306 \text{ lbs.} \times 89.5 \text{ ft.} = 342 \text{ lbs.})

Compressive force

\[
\text{Anchor distance} \times \frac{\text{Bisect tension}}{\text{pole height}} = \frac{142 \text{ kg} \times 12.2 \text{ m}}{24.4 \text{ m}} = 71 \text{ kg}
\]

\[
\frac{306 \text{ lbs.} \times 40 \text{ ft.}}{80 \text{ ft.}} = 153 \text{ lbs.}
\]

Total load on the wire tong

\[
= \text{weight of conductor} + \text{compressive force}
\]

\[
= 43 \text{ kg} + 71 \text{ kg} = 114 \text{ kg}
\]

(95 lbs. + 153 lbs. = 248 lbs.)

209 ROPES, ROPE BLOCKS & HOISTS

Some live line work requires the use of rope. Double braid rope is the premium choice of rope for this activity. A rope used for live line work should not be used for any other purpose.

Double braid rope should be used exclusively for live line application, and be stored in a cool, dry place.

During live line work where rope is being used, a tarpaulin should be placed on the ground and all rope kept directly on it to help ensure its integrity.

Moisture and contaminants could cause deterioration in dielectric and strength performance. To absorb any moisture from the rope, a sealed plastic container with a sac of Silica Gel is recommended during storage.

Synthetic fibre ropes offer a distinct advantage to the industry. With proper care, they can be much safer,
stronger, easier to handle and, in the long run, less expensive than natural fibres. However, ropes should not be considered as insulation.

**Working Load Limits**

In determining the working load limits of rope, a safety factor of five is used. If the average breaking point in kg (lbs.) of a particular size and type of rope is divided by five, the results will give the rope’s recommended working load limit (WLL).

The following example illustrates the reason for using this safety factor. (See Table #1)

**TABLE #1**

<table>
<thead>
<tr>
<th>Breaking Strength kg (lbs.)</th>
<th>Lifted Load kg (lbs.)</th>
<th>Safety Factor</th>
<th>No. of lifts before failure (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13,608 (30,000)</td>
<td>2,250 (5,000)</td>
<td>6/1</td>
<td>1,000</td>
</tr>
<tr>
<td>13,608 (30,000)</td>
<td>2,700 (6,000)</td>
<td>5/1</td>
<td>750</td>
</tr>
<tr>
<td>13,608 (30,000)</td>
<td>3,150 (7,000)</td>
<td>4/1</td>
<td>500</td>
</tr>
<tr>
<td>13,608 (30,000)</td>
<td>4,500 (10,000)</td>
<td>3/1</td>
<td>300</td>
</tr>
<tr>
<td>13,608 (30,000)</td>
<td>6,804 (15,000)</td>
<td>2/1</td>
<td>100</td>
</tr>
<tr>
<td>13,608 (30,000)</td>
<td>9,072 (20,000)</td>
<td>1.5/1</td>
<td>25</td>
</tr>
<tr>
<td>13,608 (30,000)</td>
<td>12,700 (28,000)</td>
<td>1.1/1</td>
<td>5</td>
</tr>
</tbody>
</table>

This illustrates that the higher the safety factor used, the longer the ropes will last.

The optimum safety factor recommended for working with ropes is five. Table #2 illustrates three sizes and types of new rope and their approximate working load limits. Multiplying the weights given by five will give the approximate average breaking strength of that particular rope.
### TABLE #2

#### Approximate Working Load Limits of New Fibre Ropes

<table>
<thead>
<tr>
<th>Normal Rope Diameter</th>
<th>Polypropylene</th>
<th>Nylon</th>
<th>Double Braid Polyester/Polyester</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm (3/8 in.)</td>
<td>225 kg (500 lbs.)</td>
<td>320 kg (700 lbs.)</td>
<td>445 kg (980 lbs.)</td>
</tr>
<tr>
<td>12 mm (1/2 in.)</td>
<td>375 kg (830 lbs.)</td>
<td>567 kg (1,250 lbs.)</td>
<td>807 kg (1,780 lbs.)</td>
</tr>
<tr>
<td>16 mm (5/8 in.)</td>
<td>590 kg (1,300 lbs.)</td>
<td>900 kg (2,000 lbs.)</td>
<td>1,385 kg (3,050 lbs.)</td>
</tr>
</tbody>
</table>

**NOTE:** Data included under double braid is based on premium quality polyester sheath/polyester core rope.

Tables showing the breaking strength of various sizes and types of rope are not always available and the rope in use is not always in a new condition. A field calculation is given in (Table #3) which makes allowances for these variables and also allows for a higher safety factor, approximately 8:1, using the metric calculations and 7:1 using the imperial calculations.

**NOTE:** The use of knots would reduce the working load limits of polypropylene, nylon and double braided ropes by half.

Where ropes and blocks are attached to an energized line and are to be manipulated from the ground, install an insulated link stick in the fall line.

Where ropes, blocks or hoists are used to support tension on energized equipment or lines from a pole, crossarm or other structure, install an insulated link stick between the rope, block or hoist and the structure.

Where blocks or hoists are used to support strain through an open point in a conductor, where the two parts of the conductor may be at different potentials, install an insulated link stick in conjunction with the blocks or hoist.

Hoists used in live line tool techniques must be of the
Conductor grips should be of an approved type (preferably live line grips).

To guard against failure during operation, maintain the hoists and grips in first class mechanical condition. Each should be inspected before every use. The hoists and grips for live line tool work should only be used for that purpose and not for other types of line work, such as pulling guys.

See the IHSA Safe Practice Guide, Ropes, Rigging and Slinging Hardware, for further information on ropes.

**TABLE #3**

<table>
<thead>
<tr>
<th>Polypropylene Rope</th>
<th>Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td></td>
</tr>
<tr>
<td>Square the diameter in millimetres and multiply by two e.g. 12 mm rope</td>
<td>Square the number of eighths and multiply by 40 e.g. ½ in. rope</td>
</tr>
<tr>
<td>12 x 12 x 2 = 288 kg</td>
<td>4 x 4 x 40 = 640 lbs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nylon Rope</th>
<th>Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td></td>
</tr>
<tr>
<td>Square the diameter in millimetres and multiply by three e.g. 12 mm rope</td>
<td>Square the number of eighths and multiply by 60 e.g. ½ in. rope</td>
</tr>
<tr>
<td>12 x 12 x 3 = 432 kg</td>
<td>4 x 4 x 60 = 960 lbs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Double Braid</th>
<th>Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td></td>
</tr>
<tr>
<td>Square the diameter in millimetres and multiply by four e.g. 12 mm rope</td>
<td>Square the number of eighths and multiply by 80 e.g. ½ in. rope</td>
</tr>
<tr>
<td>12 x 12 x 4 = 580 kg</td>
<td>4 x 4 x 80 = 1,280 lbs.</td>
</tr>
</tbody>
</table>
Rope blocks are used by workers for several job applications. They provide a definite advantage in moving weights or forces, but they also have certain limitations to rig safely. The job can be made much easier, or quite dangerous, depending on the choice of blocks.

In theory, the mechanical advantage of a set of block and tackle is determined by the number of parts of rope suspending the load. For example, with four parts of rope, 0.45 kg (1 lb.) pull on the fall line should lift 1.8 kg.

**Figure #13**
(4 lbs.). However, with the load moving, and the ropes being pulled through sheaves, friction reduces this advantage. For practical purposes, there is a loss of approximately 10% for each sheave in the rope blocks.

As shown in Figure #13, the rope passing through a sheave remains in contact with the sheave over 180° of the sheave surface. This, in effect, adds 10% of the weight being moved to the amount of force to be overcome.

**Example:**
A 90.7 kg (200 lb.) weight is being lifted using a set of three sheave blocks:

- **weight** – 90.7 kg (200 lbs.)
- **friction loss** – 60% of 90.7 kg (200 lbs.) = 54.4 kg (120 lbs.)
- **total weight** – 145 kg (320 lbs.)
- **mechanical advantage** – 6

Pull on the fall line is:

\[
PFL = \frac{\text{weight} + (\% \text{ of friction loss})}{\text{mechanical advantage}}
\]

\[
= \frac{90.7 \text{ kg (200 lbs.)} + [60\% \times 90.7 \text{ kg (200 lbs.)}]}{6}
\]

\[
= \frac{90.7 \text{ kg (200 lbs.)} + 54.4 \text{ kg (120 lbs.)}}{6}
\]

\[
= \frac{145 \text{ kg (320 lbs.)}}{6}
\]

\[
= 24.2 \text{ kg (53.3 lbs.)}
\]

Therefore, the weight on the hook of the stationary block is 90.7 kg + 24.2 kg (200 lbs. + 53.3 lbs.) = 115 kg (253.3 lbs.).
SECTION III
PREPARATION FOR WORK

300 GENERAL
301 CONDUCTOR REFERENCE CHARTS
SECTION III
PREPARATION FOR WORK

300 GENERAL
1. The supervisor and the workers who are to perform the task should be familiar with the previous sections of this Safe Practice Guide:
   (a) Introduction
   (b) General Instructions – Testing, Care and Use of Equipment
   (c) Calculation of Forces
2. Obtain hold-off protection (loading on the circuit should be checked with the controlling authority, if the line is to be jumpered and/or cut).
3. Check for:
   (a) broken ties, pins, and insulators on adjacent structures
   (b) broken strands or other conductor damage
   (c) cracked or broken crossarms
4. Where elevated structures or heavy angles are encountered, the forces to be supported by the live line tools should be calculated. These forces will govern the rigging procedures.
5. Establish work area protection and traffic control in accordance with current legislation.
6. The supervisor should hold a tailboard talk with the entire crew. Items to be covered should include, but not limited to:
   (a) job safety analysis
   (b) proper rigging procedures
   (c) safe work clearances
   (d) method to be used
   (e) pertinent rules from the EUSR
NOTE: Designation of one person to act as “pole boss” may assist in communications when moving phases. (Usually the person at the guide tongs is in charge.)

7. Test the pole to be worked and rope guy where necessary.

8. If underbuild is encountered, it must be covered and/or removed in accordance with standard safe practices.

NOTE: When moving old conductors (e.g. #6 and #4 solid copper, #2 or 1/0 ACSR) inspection of the conductor is imperative.

Check sleeves, and check for kinks, burned or broken strands, or other conductor damage.

\[
90^\circ = 1\frac{1}{2} \text{ line tension}
\]

Guy tension:

\[
\frac{\text{line tension} \times \text{guy length}}{\text{anchor distance}} = \text{guy tension}
\]
## 301 CONDUCTOR REFERENCE CHARTS

1. Aluminum cable – steel reinforced

<table>
<thead>
<tr>
<th>Aluminum C.M. or A.W.G.</th>
<th>Stranding Number and Diameter of Strands (ins.)</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aluminum Steel kg/km lbs./1,000 ft.</td>
<td></td>
</tr>
<tr>
<td>795,000</td>
<td>54 x 0.1214 7 x 0.1214</td>
<td>1524 1024</td>
</tr>
<tr>
<td>795,000</td>
<td>26 x 0.1360</td>
<td>1628 1094</td>
</tr>
<tr>
<td>795,000</td>
<td>30 x 0.0977</td>
<td>1836 1234</td>
</tr>
<tr>
<td>715,500</td>
<td>54 x 0.1151 7 x 0.1151</td>
<td>1369 920</td>
</tr>
<tr>
<td>715,500</td>
<td>26 x 0.1290</td>
<td>1464 984</td>
</tr>
<tr>
<td>715,500</td>
<td>30 x 0.0926</td>
<td>1650 1109</td>
</tr>
<tr>
<td>666,600</td>
<td>54 x 0.1111 7 x 0.1111</td>
<td>1275 857</td>
</tr>
<tr>
<td>636,000</td>
<td>54 x 0.1085 7 x 0.1085</td>
<td>1219 819</td>
</tr>
<tr>
<td>636,000</td>
<td>26 x 0.1216</td>
<td>1302 875</td>
</tr>
<tr>
<td>636,000</td>
<td>30 x 0.0874</td>
<td>1469 987</td>
</tr>
<tr>
<td>605,000</td>
<td>54 x 0.1059 7 x 0.1059</td>
<td>1159 779</td>
</tr>
<tr>
<td>556,500</td>
<td>26 x 0.1138</td>
<td>1140 766</td>
</tr>
<tr>
<td>556,500</td>
<td>30 x 0.1362 7 x 0.1362</td>
<td>1296 871</td>
</tr>
<tr>
<td>500,000</td>
<td>30 x 0.1291 7 x 0.1291</td>
<td>1165 782</td>
</tr>
<tr>
<td>477,000</td>
<td>26 x 0.1054</td>
<td>978 656</td>
</tr>
<tr>
<td>477,000</td>
<td>30 x 0.1261 7 x 0.1261</td>
<td>1112 746</td>
</tr>
<tr>
<td>397,500</td>
<td>26 x 0.0961</td>
<td>814 546</td>
</tr>
<tr>
<td>397,500</td>
<td>30 x 0.1151 7 x 0.1151</td>
<td>926 622</td>
</tr>
<tr>
<td>336,400</td>
<td>26 x 0.0885</td>
<td>689 463</td>
</tr>
<tr>
<td>336,400</td>
<td>30 x 0.1059 7 x 0.1059</td>
<td>784 526</td>
</tr>
<tr>
<td>300,000</td>
<td>26 x 0.1074 7 x 0.0835</td>
<td>615 412</td>
</tr>
<tr>
<td>300,000</td>
<td>30 x 0.1000 7 x 0.1000</td>
<td>699 469</td>
</tr>
<tr>
<td>266,800</td>
<td>6 x 0.2109 7 x 0.0703</td>
<td>510 343</td>
</tr>
<tr>
<td>266,800</td>
<td>26 x 0.1013 7 x 0.0788</td>
<td>546 367</td>
</tr>
<tr>
<td>4/0</td>
<td>6 x 0.1878 1 x 0.1878</td>
<td>436 293</td>
</tr>
<tr>
<td>3/0</td>
<td>6 x 0.1672 1 x 0.1672</td>
<td>345 232</td>
</tr>
<tr>
<td>2/0</td>
<td>6 x 0.1490 1 x 0.1490</td>
<td>275 184</td>
</tr>
<tr>
<td>1/0</td>
<td>6 x 0.1327 1 x 0.1327</td>
<td>217 146</td>
</tr>
<tr>
<td>1</td>
<td>6 x 0.1182 1 x 0.1182</td>
<td>173 116</td>
</tr>
<tr>
<td>2</td>
<td>6 x 0.1052 1 x 0.1052</td>
<td>137 92</td>
</tr>
</tbody>
</table>
2. All aluminum

<table>
<thead>
<tr>
<th>Size</th>
<th>Stranding Number and Diameter of Wires</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kg/km</td>
</tr>
<tr>
<td>556,000</td>
<td>19 x 0.1700</td>
<td>787</td>
</tr>
<tr>
<td>477,000</td>
<td>19 x 0.1585</td>
<td>667</td>
</tr>
<tr>
<td>397,500</td>
<td>19 x 0.1447</td>
<td>555</td>
</tr>
<tr>
<td>336,400</td>
<td>19 x 0.1331</td>
<td>470</td>
</tr>
<tr>
<td>266,800</td>
<td>19 x 0.1185</td>
<td>372</td>
</tr>
<tr>
<td>266,800</td>
<td>7 x 0.1953</td>
<td>372</td>
</tr>
<tr>
<td>4/0</td>
<td>7 x 0.1739</td>
<td>296</td>
</tr>
<tr>
<td>3/0</td>
<td>7 x 0.1548</td>
<td>235</td>
</tr>
<tr>
<td>2/0</td>
<td>7 x 0.1379</td>
<td>186</td>
</tr>
<tr>
<td>1/0</td>
<td>7 x 0.1228</td>
<td>147</td>
</tr>
</tbody>
</table>
3. Hard drawn copper

<table>
<thead>
<tr>
<th>Size</th>
<th>Strand</th>
<th>Mass</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kg/km</td>
<td>lbs./1000 ft.</td>
</tr>
<tr>
<td>1000 MCM</td>
<td>37</td>
<td>4595</td>
<td>3088</td>
</tr>
<tr>
<td>900 MCM</td>
<td>37</td>
<td>4135</td>
<td>2779</td>
</tr>
<tr>
<td>800 MCM</td>
<td>37</td>
<td>3675</td>
<td>2470</td>
</tr>
<tr>
<td>750 MCM</td>
<td>37</td>
<td>3446</td>
<td>2316</td>
</tr>
<tr>
<td>700 MCM</td>
<td>37</td>
<td>3216</td>
<td>2161</td>
</tr>
<tr>
<td>600 MCM</td>
<td>37</td>
<td>2757</td>
<td>1853</td>
</tr>
<tr>
<td>500 MCM</td>
<td>37</td>
<td>2298</td>
<td>1544</td>
</tr>
<tr>
<td>500 MCM</td>
<td>19</td>
<td>2298</td>
<td>1544</td>
</tr>
<tr>
<td>450 MCM</td>
<td>19</td>
<td>2067</td>
<td>1389</td>
</tr>
<tr>
<td>400 MCM</td>
<td>19</td>
<td>1838</td>
<td>1235</td>
</tr>
<tr>
<td>350 MCM</td>
<td>19</td>
<td>1609</td>
<td>1081</td>
</tr>
<tr>
<td>300 MCM</td>
<td>19</td>
<td>1378</td>
<td>926</td>
</tr>
<tr>
<td>250 MCM</td>
<td>19</td>
<td>1149</td>
<td>772</td>
</tr>
<tr>
<td>4/0</td>
<td>19</td>
<td>972</td>
<td>653</td>
</tr>
<tr>
<td>4/0</td>
<td>7</td>
<td>972</td>
<td>653</td>
</tr>
<tr>
<td>3/0</td>
<td>7</td>
<td>771</td>
<td>518</td>
</tr>
<tr>
<td>2/0</td>
<td>7</td>
<td>606</td>
<td>407</td>
</tr>
<tr>
<td>1/0</td>
<td>7</td>
<td>479</td>
<td>322</td>
</tr>
<tr>
<td>No. 1</td>
<td>3</td>
<td>381</td>
<td>255</td>
</tr>
<tr>
<td>No. 1</td>
<td>7</td>
<td>381</td>
<td>255</td>
</tr>
<tr>
<td>No. 1</td>
<td>Solid</td>
<td>377</td>
<td>253</td>
</tr>
<tr>
<td>No. 2</td>
<td>3</td>
<td>302</td>
<td>202</td>
</tr>
<tr>
<td>No. 2</td>
<td>7</td>
<td>302</td>
<td>202</td>
</tr>
<tr>
<td>No. 2</td>
<td>Solid</td>
<td>299</td>
<td>200</td>
</tr>
<tr>
<td>No. 4</td>
<td>3</td>
<td>190</td>
<td>127</td>
</tr>
<tr>
<td>No. 4</td>
<td>7</td>
<td>192</td>
<td>129</td>
</tr>
<tr>
<td>No. 4</td>
<td>Solid</td>
<td>188</td>
<td>126</td>
</tr>
<tr>
<td>No. 6</td>
<td>3</td>
<td>119</td>
<td>80</td>
</tr>
<tr>
<td>No. 6</td>
<td>7</td>
<td>121</td>
<td>81</td>
</tr>
<tr>
<td>No. 6</td>
<td>Solid</td>
<td>119</td>
<td>79</td>
</tr>
</tbody>
</table>
SECTION IV
SPECIFIC JOB PRACTICES
AND PROCEDURES

400 CHANGE CROSSARM AND INSULATORS
ON A TANGENT STRUCTURE

401 CHANGE DOUBLE CROSSARMS
ANGLE STRUCTURE

402 CHANGE INSULATORS ON A
VERTICAL DEAD-END STRUCTURE
SECTION IV
SPECIFIC JOB PRACTICES
AND PROCEDURES

400 CHANGE CROSSARM AND INSULATORS
ON A TANGENT STRUCTURE

NOTE: For the following specific job procedures,
the cover-up (which would normally be in place) has been removed from the diagrams for ease of explanation.

1. Preparation
The supervisor and the workers who are to perform the job should be familiar with, and have a good working knowledge of, the previous sections of this Guide which include:
(a) Introduction,
(b) General Instructions—Testing, Care and Use of Equipment
(c) Calculation of Forces
(d) Preparation for Work
(e) The EUSR

2. Method
(a) Set up at the job site in accordance with the procedures outlined in Section 400 (1) Preparation. **Task**: Change crossarm and insulators.
(b) Install pole saddles in appropriate positions offset from straight line on the side of the conductor to be lifted. (See Figures #14 and #15)

(c) Install a crossarm guard under the insulator. (See Figure #15)

(d) Attach the lifting tong to the conductor (the open side of the tong facing the pole) and tighten in the saddle.

(e) Attach the holding tong to the conductor and tighten in the saddle.

**NOTE:** If hot ties are worked on while untying, the excess tie wire should be cut off to prevent it from making contact with the crossarm or other hardware. Enough tail must be left to allow the worker to re-engage the tie stick.

(f) After the conductor is untied, lift it with live line blocks (attached from the saddle clevis to the swivel butt ring). When the conductor is clear of the insulator, let off the holding tong saddle.
This allows conductor movement to the outside of the crossarm.

**NOTE:** In certain instances, the use of a wire tong band (attached to the lifting pole) and a set of rope blocks to the top saddle clevis will aid in the control of conductor side movement. (Refer to Figure #9)

(g) When the conductor reaches the desired position, tighten the pole clamps on both saddles and check they are tight.

**NOTE:** Care must be taken not to overtighten the pole clamp on live line tools, as this may damage the surface of the tool or damage the clamp itself. The use of a screwdriver or plier handles in the butterfly nut is not recommended.

(h) Position the saddles to handle the opposite phase #2. (See Figure #16)

(i) Attach lifting and holding tongs to the conductor and tighten the saddles. Untie the conductor and move it

**Figure #16**
into position as outlined in steps (f) and (g). 
(See Figure #17)

Two outside phases supported by live line tools, in rest position, a safe distance from the working area.

(j) Attach saddles to the pole directly under the centre phase to handle phase #3 as shown in Figure #18.

**NOTE:** Top saddle has no extension. This allows for the top tongs to pass between the pole and the bottom tong.
Figure #19 shows an alternate method on the crossarm pole pin position.

**Figure #19**

**NOTE:** The saddles used for the lifting poles for phases 1 and 2 may be replaced with the lever lift attachments for insulator and/or crossarm changes. The steps remain the same.

(k) With the conductors removed from their respective insulators and a safe work area established, proceed to change the insulators and the crossarm.

(l) Attaching Conductor
   (i) Move the conductor back to its original position on the insulator by reversing the removal procedure outlined previously.
   (ii) The conductors should be moved carefully into position. Once in the insulator groove, pull down on the lift pole and tighten the saddle clamp.
   (iii) Tie in the conductor (live line loop ties or mechanical ties).
   (iv) Remove the live line tools.
NOTE: This job outline may be readily adapted to other types of line hardware, such as horizontal line post insulators, etc.

401 CHANGE DOUBLE CROSSARMS – ANGLE STRUCTURE

1. Preparation (See Figure #20.)
   The supervisor and the workers who are to perform the job, should be familiar with, and have a good working knowledge of, the previous sections of this Guide which include:
   (a) Introduction
   (b) General Instructions – Testing, Care and Use of Equipment
   (c) Calculation of Forces
   (d) Preparation for Work

2. Method
   Set up at the job site in accordance with the procedures outlined in Section III, Preparation for Work.

3. Moving Inside Conductor (Phase 1)
   (a) Install top saddle in appropriate position (offset from straight line) on the side of the conductor to be lifted.
   (b) (i) Attach the lifting tong to conductor.
          (ii) Attach the holding tong to conductor and tighten in the top saddle.
(c) Install the lever lift support to the lifting tong, and attach it to the pole.

(d) Tie a rope (of adequate size) into the butt ring of a link stick and attach the stick to the conductor. This will be used for pulling the conductor clear from behind the grooves of the insulators. (See Figure #21)

(e) Attach a set of rope blocks between this rope line and a secure object on the ground. (See Figure #22)
NOTE: The anchor point should be a distance of twice the height of the attachment away from the pole.

(f) Install a set of rope blocks between the ring on the lever lift and a snubbing bracket (placed approximately 1 m (3 ft.) above the lever lift. (Refer back to Figure #21) The conductor is now ready to be untied.

(g) Install a crossarm guard and untie the conductor.

(h) Take a slight lift on the lifting tong.

(i) Tighten the blocks on the guy rope.

(j) When the conductor is raised clear of the insulator, let off on the guy rope blocks to allow side movement of the conductor.

(k) When the conductor reaches the desired position, tighten the pole clamp on the top saddle and then remove the guy rope and link stick as bisect tension is relieved.

NOTE: Conductors must be moved slowly and under control at all times. Care must be taken when moving the inside conductors, as tension will be decreased and the sag in the adjacent spans will increase.

4. Moving Middle Conductor (Phase 2)

(a) Transfer the link stick and guy rope to the middle conductor. (See Figure #23)

(b) Attach the lifting and holding tongs and saddles, untie and move the conductor as described in preceding instructions.
NOTE: In most cases, it will be necessary to raise the middle conductor above the crossarm to gain working clearance, rather than out over the end.

(c) Tighten the saddle clamps securely to hold the wire tongs.

(d) On heavy corners, the guy rope may have to remain attached to the conductor for side support. However, on light corners, when the tension has been relieved and the saddle clamps tightened, remove the link stick and rope guy.

5. Moving Outside Conductor (Phase 3)

(a) Install the link stick and rope guy on the outside conductor.

(b) Attach the lifting and holding tongs and saddles.
(c) Untie and move the conductor to a safe location as described in preceding instructions.

(d) The link stick should be anchored securely and left attached to the outside conductor. (See Figure #24)

![Figure #24](image)

**NOTE 1:** When short spans and heavy corners are encountered, the conductor should be raised above the crossarm to gain working clearance.

**NOTE 2:** On light corners, a lever lift may be used and the conductor pulled into the corner to gain clearance. (See Figure #25)

6. **Attaching Conductors**

   (a) Once the crossarm and insulators are changed, the conductors should be returned to their normal positions by reversing the removal procedure, as outlined previously.
(b) The conductors should be moved carefully into position. Once in the insulator groove, pull down on the lifting tong and tighten the saddle clamp.

(c) Tie in the conductor.

(d) Remove the live line tools.

NOTE: This job outline may be readily adapted to other types of construction.

402 CHANGE INSULATORS ON A VERTICAL DEAD-END STRUCTURE

1. Preparation (See Figure #26)
   The supervisor and the workers who are to perform the job should be familiar with, and have a good working knowledge of, the previous sections of this Guide, which include:
   (a) Introduction
2. Method

(a) Set up at the job site in accordance with the procedures outlined in the Section III, Preparation for Work. Cover up the appropriate opposite conductors and related hardware.

(b) Using live line tools, place a nylon sling around the pole, above the insulators to be changed.

(c) Install a strain link stick in the nylon sling.

(d) Using a grip-all stick, install a live line grip on the conductor.

(e) Using a set of rope blocks, engage the beckett end block in the eye of the link stick and, using a grip-all stick, attach the running block hook to the live line grip eye.
(f) Install a link stick (with synthetic rope attached to the eye) to the eye in the fall line of the blocks.

(g) Take up tension on the fall line.
   **NOTE:** Rope should be attached to a secure anchor on the ground.

(h) Using a universal stick with a cotter key puller attached, remove the cotter key between the insulator and strain clamp.

(i) Using a universal stick with an adjustable insulator fork attached, grasp the insulator to hold it in a horizontal position.

(j) Install a wire holding stick to the conductor on or near the dead-end body and one on the permanent jumper for controlling it when disengaged.

(k) Take up tension on the blocks and disengage the insulator from the dead-end clamp.
   **NOTE:** Conductor and jumper must be held in a safe position and be under control at all times.

(l) If safe limits of approach allow, the insulator may be removed and a new one installed by hand.
   **NOTE:** In the event clearance is limited, a live line tool technique may be implemented.

(m) Using the insulator fork, raise the insulator and connect it to the dead-end clamp.

(n) Let off slightly on the rope blocks.

(o) Install a cotter key, using a cotter key installing tool.

(p) Before totally releasing the blocks, check the key and insulator to ensure proper seating.
(q) Let off on the fall line of the blocks.

(r) Using a grip-all stick, engage the fall line of the blocks above the link stick and raise toward the conductor. As the insulation value of the synthetic rope is not known, it must be considered alive when it is attached to the conductor.

(s) A second worker may now disengage the running block from the grip eye.

(t) Change the remaining insulators using the same procedure.

(u) Lower the blocks, link stick, etc., to the ground.

(v) Using a grip-all stick, remove the live line grip.

(w) Lower all tools to the ground.

**NOTE:** The worker will grasp the fall line with a grip-all stick, above the link stick, to give slack for removal of the blocks.

This method may be used to change insulators or adjust sag on horizontal construction with a slight change: the sling around the crossarm and to the side of the insulators, rather than around the pole.
Available Safe Practice Guides

• Bare Hand Live Line Techniques
• Conductor Stringing
• Entry and Work in a Confined Space
• Excavating with Hydrovacs in the Vicinity of Underground Electrical Plant
• High Voltage Rubber Techniques up to 36 kV
• Hydraulics
• Ladder Safety
• Line Clearing Operations
• Live Line Tool Techniques
• Low Voltage Applications
• Pole Handling
• Ropes, Rigging and Slinging Hardware
• Temporary Grounding and Bonding Techniques
• Underground Electrical Systems